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Effect of Hydrocooling and of Top Icing on Temperature Reduction in Carlot Shipments of Crated Green Sweet Corn.

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EFFECT OF HYDROCOOLING AND OF TOP ICING ON TEMPERATURE REDUCTION IN CARLOT SHIPMENTS OF CRATED GREEN SWEET CORN

Sweet corn is a new commercial crop in Florida. Production of this commodity has increased from approximately four carloads during the season of 1940-41 to more than 5,400 carlot equivalents in 1950-51, valued at approximately 7-3/4 million dollars. Although shipments are made from October to July, the bulk of the movement takes place during April, May, and the first half of June, when the daily temperatures commonly rise into the high 80°s or low 90°s. This phenomenal expansion in production during the past ten or twelve years, mostly during the past four or five years, is due, in part, to the introduction of better varieties, the development of better pesticides more effectively applied, and to improvements in handling of the commodity all along the line from the field to the consumer. No such expansion in production would have taken place if the consumer had not been supplied a product acceptable to him, even though it probably had lost considerable quality during the handling period.

It is common knowledge among gardeners that the eating quality of sweet corn does not improve after it is harvested, and that "roasting ears" taste best when cooked immediately after they are pulled from the stalk. It is also common knowledge that sweet corn remains sweet longer in a cold refrigerator than on a warm porch.

Experience has convinced most shippers that green sweet corn, one of the most perishable of all vegetables, should be precooled and given the most effective refrigeration service during the transit period. They also know that tender, sweet corn held at ordinary temperatures is quickly converted to tough, starchy, "mule corn" and that there is a definite correlation between deterioration in eating quality and loss of sweetness or sugar. Yet, there is little data at hand which show precisely the hourly rate of loss of sugar at different temperatures, or the rate of temperature reduction obtained from hydrocooling and later from standard refrigeration supplemented by top icing.

In order that the shipper may have a definite picture of the effect of temperature on the rate of sugar loss in green sweet corn, a graph, figure 1, is here reproduced from a study reported on by C. O. Appleman and J. M. Arthur. "Carbohydrate Metabolism in Green Sweet Corn During Storage at Different Temperatures", in the Journal of Agricultural Research, 17: 137-152, 1919. This graph shows the rate at which sugar losses occur over a four-day period at four definitely maintained temperature levels spaced at 18-degree intervals between 32° and 86°. As much sugar is lost in three or four hours at 86° as in about 22 hours at 50°, or in four days at 32°. Twenty-five percent of its sugar is lost in four or five hours at 86°; or in 26 to 28 hours at 50°. Fifty percent of its sugars is lost in about 16 hours at 86° or in about three days at 50°. In four days at 32°, about 20 percent of the sugar is lost; at 50°, about 60 percent is lost, and at 68°, about 70 percent is lost.

From these data it is seen that while loss of sugar cannot be entirely prevented even by refrigeration at temperatures as low as 32°, it can be retarded by quickly reducing the commodity temperature as much as is possible through the judicious use of persent-day precooling facilities, followed by the best refrigeration-in-transit practices, and by a continuation of proper refrigeration after the commodity is removed from the car at the distributing centers.

Thus the necessity for eliminating all unnecessary delay in lapsed time between harvesting and precooling to a temperature level of 40° or lower is obvious, particularly when the objective is to deliver to the consumer a quality product in a condition approaching that of garden freshness.

Repeated requests have been made by the industry for information on the amount of heat removed from crated green sweet corn when it is precooled in hydrocoolers under actual commercial operation and whether fan cars or non-fan cars are better suited for the shipment of precooled and top-iced loads of corn. Some receivers or their representatives in the field believe that even though crated green sweet corn should be precooled and top-iced, it should not be given fan service during the transit period, because of the assumed risk of freezing and/or causing the product to wilt.

In compliance with these requests, a series of tests, commercial in every respect, was planned to: (1) determine the amount of heat removed from crated green sweet corn as it passes through the precooling facilities (hydrocoolers) currently available to Florida shippers; (2) establish the rate of cooling at different levels in the car during the transit period in pre-iced end-bunker refrigerated cars, top-iced at loading point and shipped under standard refrigeration; (3) compare the standard lengthwise method of loading and the crisscross method; and (4) compare the performance of fan and non-fan car services. Tests were made in late May and June 1950, and again from late March to early June, 1951, when the minimum daily temperatures hovered around 72°, while the maximum was often in the 90°s.

MATERIALS AND METHODS

The corn in its husk was packed in wirebound crates of two capacities designated in the Container Authorizations of the Freight Tariff Bureau as: (1) the corn container No. 3730, with inside dimensions of 9" x 11" x 21-7/8" carrying a billing weight of 43 pounds, and (2) the vegetable container No. 5007 with inside dimensions of 9" x 13" x 22", carrying a billing weight of 50 pounds. Packing was done either in the field or in a shed at the precooling plant. Usually the crated corn was passed through a hydrocooler within an hour or two after it was picked but sometimes there was six or eight hours of summer heat between picking and precooling.

The hydrocoolers used in these tests, of the type common in Florida, consist of a large rectangular tank approximately 50 - 58 feet long through which the crated commodity moves slowly on a conveyor on its way from the packing or receiving shed to the car. The level of the water in the tank was held high enough to keep the containers partially submerged. The water was kept cold by pumping it from the tank into slotted troughs above each bank of cooling coils, suspended from the ceiling, running lengthwise of the tank. As these slotted troughs overflowed, the falling water showered over the cold coils to the partially submerged line of crates below, thence back to the pump.

While no dependable temperature records of the water in the hydrocooler were obtained, it is unlikely that the water immediately surrounding the crates was much below 40° most of the time that corn was passing through without interruption.

The temperature of the cooling water was controlled largely by the rate of movement of the produce through the tank. At times the cooler was overloaded with warm produce, resulting in a moderate rise in temperature of the water in the tank. The aim was to expose the packages to the cold bath for thirty minutes. In a few instances, the produce was stopped in the cooler for a longer period, e.g., when the crates were left in the cooler with compressors and water pumps operating until the next truck load arrived. After passing through the hydrocooler, a chain conveyor took the produce to a pre-iced car within a minute or two, thus there was no significant rise of commodity temperature between the cooler and the car.

In order to establish the amount of cooling obtained from the commercial hydrocoolers, ten or more cob temperatures were taken in each carlot as the crates moved into the cooler and again as it emerged from the cooler. At both times, crates were picked at random, they were opened and an ear was selected from the center of the crate. After cutting off the shank close to the base of the cob, a fruit thermometer was inserted about 2 1/2 inches into the butt-end of the cob.

Temperature records during the transit period, from loading point to destination, were made by a recording thermometer placed in the center of each of three precooled crates in each car as it was being loaded. These test crates were placed in the bottom, middle, and top layers at the quarterlength position along the centerline of the car and were left in place until the car was unloaded.

Two loading methods were followed: (1) the conventional lengthwise method calling for eight rows with crates placed end to end mostly in four layers; and (2) the so-called crisscross or "crib" load. This is a seven-row-five-layer load in which the crates in the first, third, and fifth layers are placed lengthwise while in the second and fourth layers the crates are placed crosswise. The lengthwise method of loading was usually

used with the larger crates and the crisscross or open method was usually employed with the smaller crates. This open method of loading afforded a liberal space between crates, so patterned to permit a considerable amount of top ice to fall between the crates. Soon after loading was completed, from 7 1/2 to 12 tones of snow ice was blown over the top of each load. All cars were pre-iced and billed to receive standard refrigeration during transit. Only three cars were re-top-iced in transit, two at Baltimore, and one at Jersey City. Eleven cars were re-top-iced at destination and the ice bunkers of twelve cars were replenished there. While most of the cars were shipped to the New York area, a few went to the Middle West.

RESULTS

Precooling

Records of commodity temperature reduction during hydrocooling were obtained from 23 carlots of corn, Table 1. As the packaged corn entered the precooler, the commodity temperatures ranged from 74.8° F. to 91.3°, with an average of 85.6°. The crates were in the precooler from 20 minutes to two hours, mostly 30 minutes, and during the precooling from 18.4 to 47.6 degrees were removed, resulting in an average temperature reduction of 27.4 degrees. The least cooling occurred in the lots held the shortest period, 20 minutes, in the cooler while the greatest amount of cooling occurred in the lots left in the cooler for two hours, the longest period.

The rate of cooling was influenced by the size of the crate. By comparing the temperature of the crates that were hydrocooled for a similar period, 30 minutes, it is seen that the lots packed in the smaller crates had an average temperature of 84.6° as they entered the cooler while those in the larger crates averaged 86.0°. The former lost 29.8 degrees during precooling while the latter, with a slightly higher entering temperature, lost only 24.0 degrees.

Comparison of Cars

Ten tests were made in cars with air circulating fans and twelve in cars without fans or when necessary, fan cars with the fans "OFF." Fig. 2 and 3. The average temperature of the commodity loaded in fan cars was 85.2° F. before it was precooled. Immediately following precooling, the average temperature was 58.9°, a reduction of 26.3 degrees. In the cars without fans the average temperature of the commodity before precooling was 85.6°, and immediately after precooling it was 57.5°, a reduction of 28.1 degrees.

At the first midnight after loading and before the cars had been made up into a through train, the average of the temperature readings in the top, middle, and bottom layers was 52.1° F. in the fan cars. At each midnight thereafter, it was 39.8°, 37.6°, 37.0°, 37.6°, and 39.4° the sixth night after loading.

The first midnight after loading, the average temperature in the top, middle, and bottom layers was 53.9°F in the cars without fans. The next night it was 48.2°, and at each succeeding midnight, it was 45.0°, 42.8°, 42.4°, and 42.3° at the sixth midnight after loading.

A summary table of these average temperatures is given in order to aid in making a quick comparison of them.

AVERAGE TEMPERATURES IN TRANSIT

Car	At Loading	Midnight					
		1st	2nd	3rd	4th	5th	6th
Fan	58.9°	52.1°	39.8°	37.6°	37.0°	37.6°	39.4°
Non-fan	57.5°	53.9°	48.2°	45.0°	42.8°	42.4°	42.3°
Difference	1.4°	1.8°	8.4°	7.4°	5.8°	4.8°	2.9°

This tabulation shows that the average temperature of the loads in the fan cars was lower than that in the non-fan cars. The difference was less than 2 degrees until after the train left the assembly yards; the second midnight, the difference was more than 8 degrees; the next midnight more than 7 degrees; and the fourth night after the cars had reached the final destination, the difference was almost 6 degrees.

At no time during the transit period of the fan cars, figure 2, was there more than a few degrees spread in temperature between the coldest and warmest layers, and the temperatures in the middle and top layers were almost identical. From about noon of the day after loading until unloading several days later, all parts of the load in the fan cars were cooler than the coldest part of the non-fan cars, figure 3, and the difference, particularly in the middle layer of the latter car, was great enough to be of considerable importance.

There was an appreciable spread in temperature in the cars without fan during most of the transit period; in these, the bottom layer was the coldest and the middle layer the warmest. There was about 9 degrees spread in temperature by noon of the day after loading between the warmest and coldest parts of the load. This spread lessened gradually during the transit period until the cars reached destination; there the spread was about 4 degrees. The coldest part of the load in these cars was a few degrees warmer than the warmest part of the load in the cars with fan service.

Comparison of Loading Methods

It has been pointed out that the temperature of corn in the smaller crates is reduced more rapidly during hydro-cooling than that in the larger crates. When the carlots are separated by types of car and further divided

by methods of loading, which for the most part also involved different size crates, it is seen, in Table 2 and Figure 4, that the highest temperatures during the transit period occurred in the lengthwise load in the non-fan car. The crisscross, or crib load, in the non-fan car cooled about as rapidly as either the crisscross or lengthwise load in fan cars. A possible contributing factor to the rapid cooling of the smaller crates in the non-fan car was that more of the top-ice was spread down between the crates of the lengthwise load.

Condition of Commodity at Unloading

Without exception, each load arrived at destination in a sound condition and was accepted without protest against the condition of the load or the quality of the product.

Crate Breakage

Since crates were often tossed into position during loading, the crate breakage that called for recoopering was small when roughness of loading is taken into consideration. According to the reports from destination inspections, there was an average of 11.4 [redacted] of the smaller crates and 16.1 [redacted] of the larger crates per car that needed recoopering. When compared by loading methods, the breakage averaged 9.4 crates per car in those with crisscross loads (mostly of small crates), and 17.2 crates per car in those loaded lengthwise, (mostly the larger crate).

Ice Consumption

Since all cars were given standard refrigeration, the bunkers were kept supplied during the transit period. The amount of bunker ice supplied en route ranged from 5,200 pounds to 20,300 pounds, Table 3, whereas the average amount supplied was 10,267 pounds per car. The average ice meltage during the transit period amounted to approximately the poundage of ice supplied during that period.

The top ice supplied at shipping point ranged from 15,000 pounds to 24,000 pounds, with an average of 18,667 pounds. Only three of the cars were re-top-iced en route. Most of the cars shipped in late June were re-top-iced at destination, and three cars received two re-top-icings there. The data regarding the amount of top ice found at terminal inspection was not always specific since they showed a range from "very little" to "plenty", or were sometimes expressed in a range of inches. The top ice remaining at destination was not evenly distributed over the load and the amount varied from car to car. In some cars, only scattered "islands" of ice remained at unloading time, while in others, the load was well covered. There was a slight rise in commodity temperature in a few cars during the holding period at destination prior to unloading, indicating that more top-ice was called for.

DISCUSSION

The reproduced graph, figure 1, showing the rate of sugar loss at different temperatures gives convincing evidence of the need for thorough precooling promptly applied if sweet corn of maximum quality is the objective of the shipper. A better product would result if the commodity were precooled to a temperature of 40° or below within an hour or two after picking and held at that level or somewhat lower until it is prepared for cooking. Under the most favorable commercial operations, corn probably loses at least 25 percent of its sugars before it reaches the consumer, while 50 percent may be nearer the amount lost under present practices.

Although it is generally recognized that sweet corn should be precooled and shipped to market under refrigeration, the amount of heat removed during precooling and the temperatures attained during transportation are not so well known. The prevailing opinion among growers and shippers alike is to the effect that the commodity is reduced to a lower temperature during precooling than is actually the case. The precooling tests reported on herein show that crated green corn with a cob temperature in the 80°s, hydrocooled for about 30 minutes is likely to have a cob temperature in the 50°s, at the end of the precooling period. The reduction is likely to range from 20 degrees to 30 degrees with an average close to 25 to 30 degrees; the cooler the commodity when it enters the hydrocooler, the less the total heat removal during a given period.

Somewhat lower commodity temperatures may be expected both from precooling and later in transit in non-fan cars when corn is packed in the Florida Corn Crate No. 3710, than when it is packed in the Vegetable Crate No. 5007.

The lengthwise load in fan cars cooled more uniformly than similar loads in non-fan cars.

The crisscross load cooled uniformly in both non-fan and fan cars and in non-fan cars it was equal in uniformity of temperature to the lengthwise load in fan cars.

In fan cars, top-iced, and moving under standard refrigeration, the commodity is likely to average about 40 degrees by midnight of the day after loading. In non-fan cars, the rate of cooling after loading is likely to be slower. Even in fan cars, the commodity temperature is not likely to fall below 35 degrees during the transit period when no salt is added to the bunker ice.

Since all the cars were preiced, given standard refrigeration and the load top-iced at loading point, the refrigeration service in transit cannot readily be improved upon except through the addition of salt to the bunkers at the first icing station. If and when re-top-icing is called for,

it probably should be given about 36 to 40 hours after loading, or the morning of the second day after loading. However, the first available top-icing facilities for eastern and middle western shipments are at Baltimore, Md. and Cincinnati, Ohio. In hot weather, when the precooling facilities are being operated to capacity, or otherwise overloaded, the maximum amount of top-icing is called for. The important objective is to get the commodity temperature into the 30°s as quickly as circumstances will permit.

The superiority of the fan car over the non-fan car for shipment of green corn was most pronounced when the crates were loaded lengthwise. The rate of cooling in the crisscross load, which permits the top ice to fall more readily between the crates, was not so greatly affected by air circulation.

Some cars were unloaded soon after arrival at destination, others were held for varying lengths of time before unloading. The apparent rise in commodity temperatures at destination as shown in some of the figures was due, in part at least, to a decreasing number of cars from which to compute averages.

For those who want to do a better job of refrigeration than is now being done, some of the following suggestions may be pertinent:

1. Consider the possibility of precooling corn before it is packed.

2. Precool corn as soon as possible after it is picked, bringing the commodity temperature to 40°, if possible.

3. Use the smaller crate.

4. Use the fan cars whenever possible.

5. Follow the crisscross method of loading.

6. Top ice promptly with as much ice as circumstances will permit.

SUMMARY

Presently operated hydrocoolers reduced the temperature of warm crated green corn from the 80°s into the 50°s in 30 minutes.

The fan car cooled the load faster in transit and gave a more uniform temperature than the non-fan car. Probably more generous initial top-icing would accelerate cooling during the transit period.

All parts of the load in fan cars reached 40° by midnight of the day after loading and remained between 35 and 40 degrees during the remainder of the trip. The coldest layer in the non-fan cars did not reach 40° and the warmest was not below 45° during the transit period.

From the standpoint of refrigeration and of breakage during transit, the smaller crate, No. 3730, is better suited to Florida operations than is the larger crate No. 5007 with shipments of crated green sweet corn.

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TABLE 1.

PRE-COOLING OF GREEN SWEET CORN IN COMMERCIAL HYDRO-COOLERS

COMMODITY PACKED IN FLORIDA CORN NO. 3730 AND VEGETABLE CONTAINER NO. 5007

WIREBOUND CRATES Season: 1950 - 1951

Test	Date	Car Initial & Number	Loading County	Loading Period	Cob temp's. Before Precooling	Cob temp's. After Precooling	Degrees Heat Removed	Minutes in Hydro-cooler
	1950							
2*	6-20	FGE 39343	Seminole	11:00a-1:15p	83.7	----	----	60
3	6-20	WFE 66555	Seminole	4:00p-7:00p	84.8	56.2	28.6	60
4*	6-21	WFE 66635	Seminole	4:45p-7:30p	86.4	58.3	28.1	90
5*	6-22	FHIX 918	Seminole	12:30p-4:15p	87.3	48.0	39.3	90
6	6-22	STRD 9874	Orange	9:00a-4:00p	87.3	58.9	28.4	30
7	6-22	URT 81641	Orange	1:30p-2:15p	83.8	62.6	21.2	30
8	6-22	WFE 72292	Orange	5:30p-6:00p	86.8	67.9	18.9	30
9	6-22	FGE 10937	Orange	6:30p-8:00p	87.9	68.8	19.1	30
10	6-23	WFE 68649	Orange	10:45a-12noon	83.8	57.2	26.6	30
11	6-23	MDT 9940	Orange	2:45p-3:15p	88.8	65.8	23.0	30
12	6-23	WFE 68446	Orange	1:45p-3:00p	90.8	61.2	29.6	30
13	6-23	MDT 10582	Orange	7:00p-8:45p	91.3	59.6	31.7	30
14	6-23	URT 81555	Seminole	4:15p-7:30p	89.9	42.3	47.6	120
	1951							
1*	3-29	FGE 38607	Palm Beach	5:55p-6:30p	86.3	54.6	31.7	30
2*	4-18	FGE 18715	Palm Beach	4:00p-5:45p	86.3	60.8	25.5	25
3*	4-18	WFE 68741	Palm Beach	10:00p-11:00p	81.2	62.8	18.4	20
4*	4-19	WFE 65171	Palm Beach	9:00a-2:55p	78.5	56.3	22.2	30
5*	4-20	FGE 36529	Palm Beach	6:00p-6:30p	86.6	58.9	27.7	30
6*	4-20	FGE 39049	Palm Beach	4:25p-4:55p	88.6	57.8	30.8	30
7*	5-29	FGE 59841	Orange	10:05p-10:30p	83.4	52.1	31.3	30
8*	5-29	FDE 9120	Orange	9:10p-9:35p	84.1	49.2	34.9	30
9	5-31	MDT 9699	Orange	5:05p-5:55p	84.6	65.3	19.3	30
10	5-31	NP 92928	Orange	1:05p-1:40p	85.7	61.8	23.9	30
11	6--1	MDT 10675	Orange	12:15p-5:45p	74.8	52.0	22.8	30
Average					85.6 1/	58.2	27.4	

THIRTY (30) MINUTES HYDRO-COOLING ONLY

Comparison of Crates

No. Tests	Type Crate	Average Temperatures Before Precooling Degrees	Average Temperatures Heat Removed Degrees
6	Florida Corn No. 3730	84.6	29.8
11	Vegetable Container No. 5007	86.0	24.0

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* Florida Corn Crate

1/Does not include test 2, 1950

TABLE 2.

FLORIDA GREEN SWEET CORN IN WIRE-BOUND CRATES

HYDRO-COOLED AND SHIPPED UNDER STANDARD REFRIGERATION

1950 - 1951

Test Number	Fans	Loading Method	Billed Weight	Total Crates	Tariff Number of Crate	Destination
1950						
2	OFF	criss-cross	24,467	569	3730 1/	New York City
3	ON	criss-cross	28,000	560	5007 2/	New York City
4	ON	criss-cross	24,080	560	3730	Chicago
5	OFF	criss-cross	24,080	560	3730	Chicago
6	ON	lengthwise	27,500	550	5007	New York City
7	NONE	lengthwise	27,500	550	5007	New York City
8	ON	lengthwise	27,500	550	5007	New York City
9	NONE	lengthwise	27,500	550	5007	New York City
10	ON	lengthwise	27,500	550	5007	New York City
11	OFF	lengthwise	27,500	550	5007	New York City
12	ON	lengthwise	26,600	512	5007	New York City
13	OFF	lengthwise	27,500	550	5007	New York City
14	NONE	criss-cross	22,500	450	5007	Hartford
1951						
1	ON	criss-cross	24,080	560	3730	Chicago
2	NONE	lengthwise	24,080	560	3730	Cleveland
3	OFF	lengthwise	27,520	640	3730	New York City
4	NONE	criss-cross	24,080	560	3730	Chicago and Milwaukee
5	NONE	criss-cross	24,080	560	3730	Philadelphia
6	ON	criss-cross	24,080	560	3730	Chicago
7	NONE	criss-cross	24,080	560	3730	New York City
8	NONE	criss-cross	24,080	560	3730	New York City
9	ON	lengthwise	25,000	500	5007	New York City
10	ON	lengthwise	25,000	500	5007	New York City
11	ON	lengthwise	24,000	480	5007	New York City
Average			25,512.8	545.9		

1/ Florida Corn Crate 9" x 11" x 21-7/8" inside dimensions.
2/ Vegetable Container 9" x 13" x 22" inside dimensions.

TABLE 3.

ICING RECORD

PRECOOLED FLORIDA GREEN SWEET CORN SHIPPING TESTS 1950 - 1951

IN CARS WITH AND WITHOUT FAN SERVICE

Test Number	Fans	Ice Supplied						Terminal Inspection		Interval between loading & unloading
		At Origin		En Route		At Destination				
		Bunker Ice	Top Ice	Bunker Ice	Top Ice	Bunker Ice	Top Ice [1]	Bunker Ice	Top Ice Notation	
1950		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.		Days
2	OFF	9,600	22,000	10,200	0	2,300	3,000	8,500	4,000 lbs.	5
3	ON	9,600	20,000	10,700	0	2,300	0	8,500	1,500 lbs.	5
4	ON	9,600	24,000	10,200	0	0	0	no record	no record	8
5	OFF	9,600	24,000	9,100	0	0	0	8,700	8-20 in.	4
6	ON	11,300	15,000	8,400	0	3,000	2,000	8,500	5,000 lbs.	6
7	NONE	8,600	15,000	12,800	0	9,100	5,000	8,600	3,000 lbs.	7
8	ON	9,600	15,000	12,300	0	8,600	18,000(2)	8,500	4-10 in.	10
9	NONE	9,600	15,000	14,300	0	6,800	10,000	8,600	2--6 in.	7
10	ON	9,600	15,000	20,300	5,000	2,200	8,000	8,600	1--4 in.	9
11	OFF	10,700	15,000	18,300	5,000	2,300	8,000	9,600	1--4 in.	11
12	ON	9,600	15,000	12,600	0	5,700	6,000(2)	5,500	6 in.	9
13	OFF	10,700	15,000	5,200	0	3,100	9,000(2)	10,000	4-11 in.	6
14	NONE	9,600	24,000	11,100	6,000	0	0	no record	plenty	6
1951										
1	ON	9,600	20,000	7,600	0	0	0	no record	very little	7
2	NONE	9,600	20,000	11,400	0	0	0	no record	plenty	5
3	OFF	10,000	20,000	5,300	0	0	4,000	8,500	4--8 in.	6
4	NONE	9,600	20,000	14,700	0	1,200	0	8,700	4--8 in.	4
5	NONE	9,600	20,000	6,300	0	0	0	7,200	4--8 in.	6
6	ON	9,600	20,000	12,200	0	1,000	0	9,000	good layer	5
7	NONE	10,000	20,000	5,200	0	0	0	8,500	heavy	5
8	NONE	9,600	20,000	5,700	0	0	0	8,500	8-20 in.	5
9	ON	10,700	18,000	5,800	0	0	4,000	9,000	heavy	5
10	ON	10,700	18,000	9,300	0	0	0	9,300	4-10 in.	3
11	ON	10,700	18,000	6,800	0	0	0	9,500	6-12 in.	4
Average		9891.7	18666.7	10266.7	666.7	1983.3	3208.3	7945.5		5.9

1/ Number in parenthesis indicates the number of times top ice was replenished at destination.

FIGURE 1.

Depletion of sucrose in sweet corn during consecutive 24-hour periods of storage, expressed as percentages of the initial sucrose in the corn, which was 3.87 percent, wet weight.

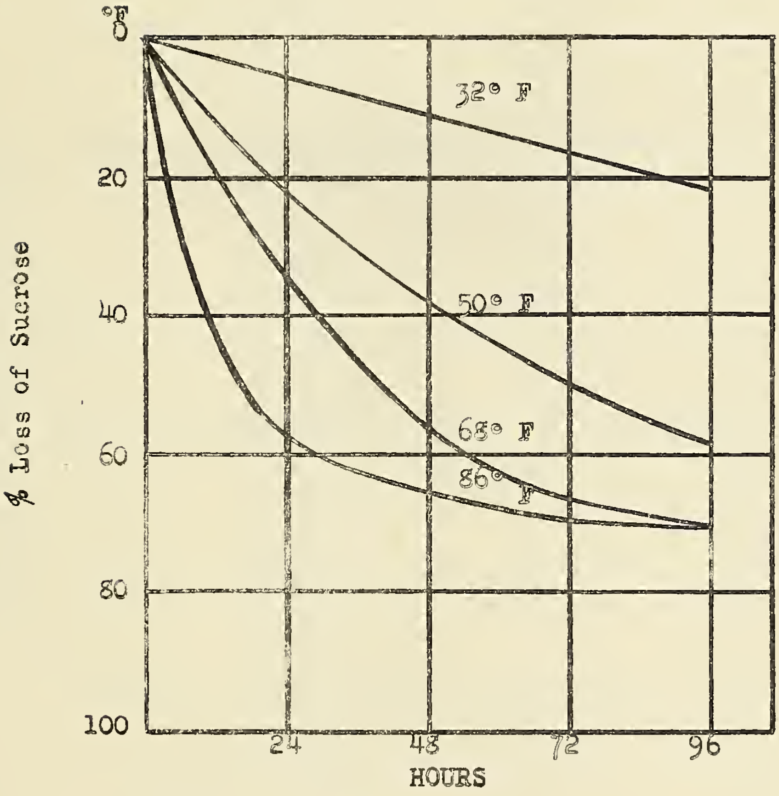
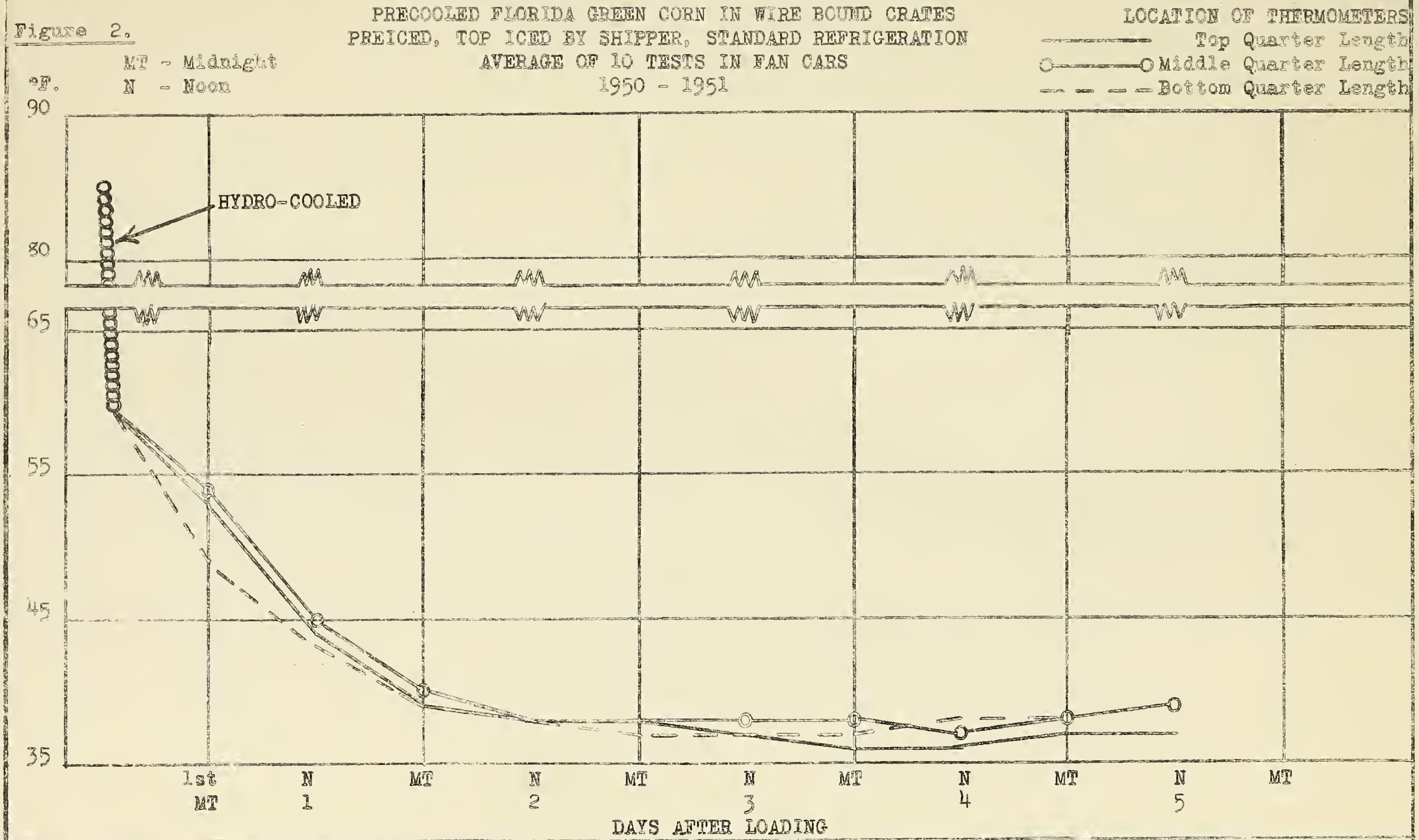


Figure 2.

AVERAGE TEMPERATURES IN TRANSIT
PRECOOLED FLORIDA GREEN CORN IN WIRE BOUND CRATES
PREICED, TOP ICED BY SHIPPER, STANDARD REFRIGERATION
AVERAGE OF 10 TESTS IN FAN CARS
1950 - 1951



AVERAGE OF 10 TESTS
Ice Supplied Lbs.

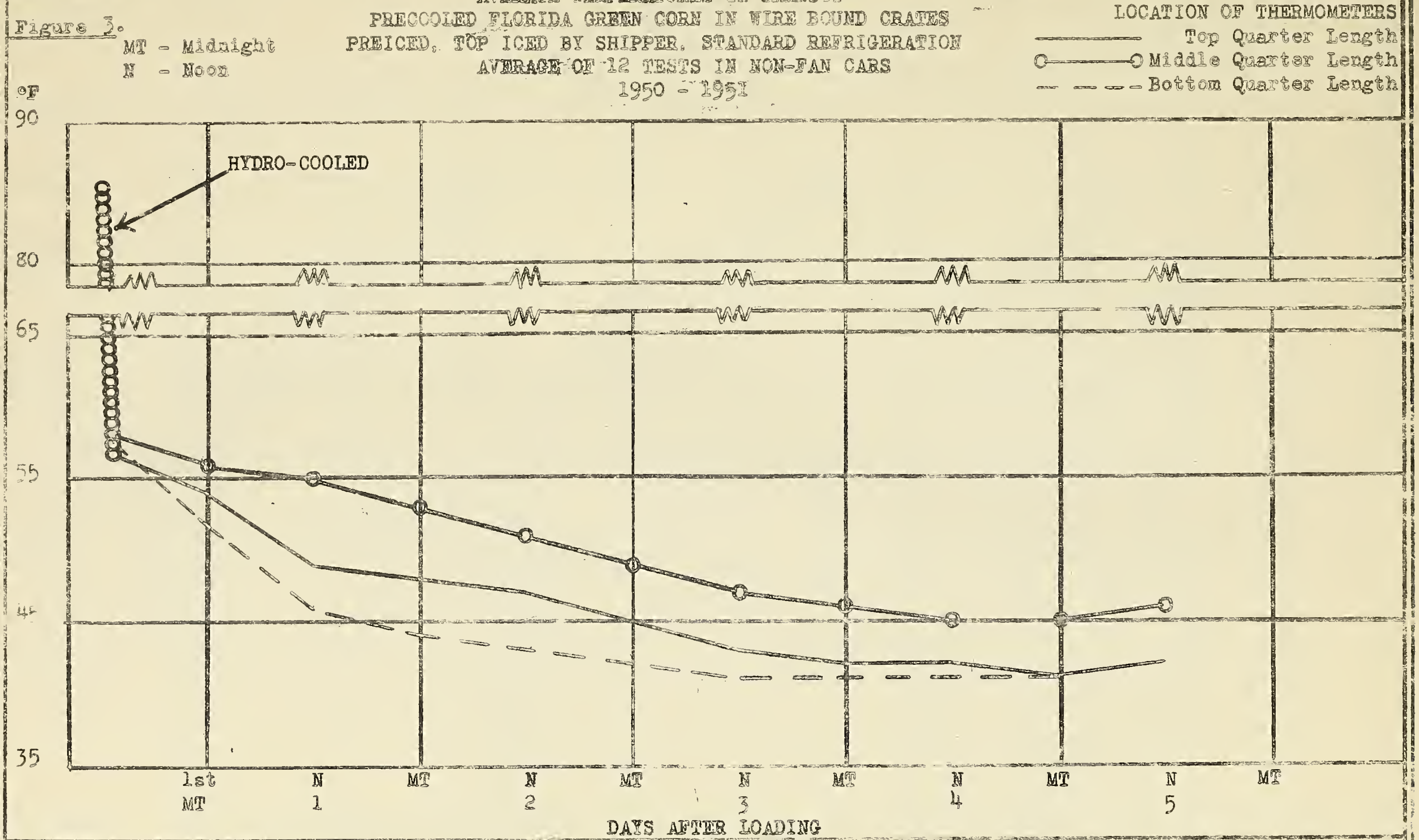
Billed Weight Lbs.	Bunker Ice		Top Ice	
	At Origin	En Route	At Loading	En Route
25,758	10,055	10,618	18,000	**

**Only one car received top ice en route, at Baltimore, fifth day after loading.

Figure 3.

MT - Midnight
N - Noon

AVERAGE TEMPERATURES IN TRANSIT
PRECOOLED FLORIDA GREEN CORN IN WIRE BOUND CRATES
PREICED, TOP ICED BY SHIPPER, STANDARD REFRIGERATION
AVERAGE OF 12 TESTS IN NON-FAN CARS
1950 - 1951



AVERAGE OF 12 TESTS
Ice Supplied Lbs.

Billed Weight Lbs.	Bunker Ice At Origin	Bunker Ice En Route	Top Ice At Loading	Top Ice En Route
25,304	9,754	9,969	13,231	**

**Only two cars received top ice en route, at Baltimore and Jersey City, respectively

MT signifies Midnight
N signifies Noon

FIGURE 4.

AVERAGE COMMODITY TEMPERATURES IN TRANSIT

COMPARISON OF LOADING METHODS IN CARS WITH AND WITHOUT FAN SERVICE

LOCATION OF THERMOMETERS
——— Top Quarter Length
– – – Middle Quarter Length
—×— Bottom Quarter Length